

Range Finding Test of *Scirpus grossus* on Aluminium and Iron Contaminated Soil

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Abstract—High concentration metal in soil may cause pollution. Particularly for aluminium and iron in soil. Even though these substances are necessary micro-substances for plants, but if the soil has it in high concentration, it will cause more complex environmental problem. These two metals were found in high concentration in soil near the small Industry Environment that recycled aluminium in Jombang Regency, East Java. High concentration also caused soil contamination, thus treatment towards the land was needed. One of the best solutions to overcome land contamination was phytoremediation. *Scirpus grossus*, to date, is the most widely used wild plant which has the ability in remediating metal pollutant in soil. Before treating metal on soil, toxicity test needed to be done beforehand. Toxicity test was done using Range Finding Test (RFT) method for 7 days using reactors with each filled with 5 kg of soil and 4 plants. RFT was done in different concentration composition between Al:Fe. The load variation (mg/kg) of Al:Fe in the reactors were 10.000:0, 5.000:50, 500:500, 50:5.000, 0:10.000 and control reactor. The result obtained after 7 days were that *Scirpus grossus* plant could survive in pollution load of Al:Fe 500:500 (mg/kg) with 75% percentage of living plants.

Keywords—Aluminium, Iron, *Scirpus grossus*, Range Finding Test

I. INTRODUCTION

Aluminium recycle industry in Jombang Regency, Jawa Timur, had been operating for more than 30 years. In yearly report by local environmental agency, Dinas Lingkungan Hidup Kabupaten Jombang, aluminium and iron substance was found in the ground near the area [1]. Aluminum metal itself is carcinogenic towards human [2]. Not only for human, aluminium in high concentration is also toxic towards plants [3]. Aluminium poisoning in plants are characterized by plant productivity decrease, beginning with the slowing down of root cell elongation, which in turn decrease nutrition absorbing [4]. Not like aluminium, iron is very important for growth and usually is considered as macronutrient and is responsible as energy transformation in synthesis process [5]. Even though iron is not considered toxic metal, but its interaction with toxic metal is very important. Iron has the ability to absorb a lot of elements and can participate to weaken heavy metals such as manganese, nickel, and cobalt, which can reduce absorption and translocation of iron and decrease chlorophyll amount in leaves [6], [7].

Phytoremediation can improve land and groundwater condition that have been polluted by dangerous heavy metal, radio nuclide, and organic contaminants [8]. The use of hyperaccumulator plant like *Scirpus grossus* is appropriate to apply. In previous [9] study, *Scirpus grossus* could remove aluminium and iron contaminants up to 33,3% in polluted water.

In this study, artificial waste was made from salt metal of $AlCl_3$ and $FeCl_3$ diluted by aquadest, made in laboratory of remediation, Laboratorium Remediasi Teknik Lingkungan ITS. The aim of this study was to analyze the toxicity rate of Al and Fe towards *Scirpus grossus* and to determine if this plant can be categorized as hyperaccumulator for Al and Fe metals.

Range Finding Test (RFT) to determine the maximum Al and Fe concentration where the *Scirpus grossus* could survive without disturbing the metabolism of plants. This RFT method was the starting step of phytoremediation process.

II. METHOD

This study was done in laboratory scale. Metal material in this study used salt metal of $AlCl_3$ dan $FeCl_3$ which were produced by SAP. The first step of this study was to make 50.000 mg/l stock solution by mixing 1 liter of tap water with each metal salt based as needed (50.000 mg/l). Contaminated soil was made from the mix of Al and Fe based on each pollutant load with 5 kg of sieved and dried soil. The pollutant load (mg/kg) variations of Al and Fe were 10.000:0, 5.000:50, 500:500, 50:5.000 and 0:10.000.

The reactors used were 5l volume plastic filled with 5 kg of soil as plantation media as seen in Figure 1.

Each reactor contained 4 *Scirpus grossus*. The amount of plant in the reactor was counted based on its specific density. *Scirpus grossus* was taken from the second generation with the same age. Acclimatization was done for a week to let the plants adapt. Observation for this study was done for 7 days by observing physical change on plants and compare it with control.

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III. RESULTS AND DISCUSSION

This research has some parameters, they were pH, temperature and moisture. As seen in Table 1, the activity plants in absorbing nutrients in soil is also influenced by the ideal pH. The optimum pH for *Scirpus grossus* 4-9 [10], so that the pH of the research reactor is still in the optimum pH range of plants to growth ideal.

Temperature is one of the environmental factors that affect plant growth and development. Temperature analysis in this study was conducted every 7 days. The results of the study on temperature parameters, in the *S. grossus* reactor ranged in temperature from 25 to 35 °C. The temperature of this reactor is still included in the optimum plant temperature, 10 - 38 °C [11]. The range of the reactor is still within the optimum temperature range for plants to do the ideal process, this is because plants can work to absorb nutrients optimally because they are influenced by ideal temperatures.

Moisture of reactors mostly 100%, This is because the plants used in this study are aquatic plants, besides the

addition of aluminum and iron contaminants in the form of a solution causes the reactor to reach a holding capacity to water. This condition that matches the holding capacity causes the reactor soil to be always saturated with water. This condition of saturation of water causes soil moisture to become high.

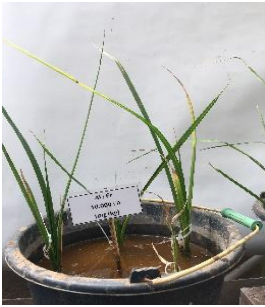





Scirpus grossus could survive in reactor with Al:Fe ration 500:500, 5.000:50, and 10.000:0 during 7 days of observation. This was proved by the percentage of living plant which reached 75-100%. The documentation of living plants comparison up to day 7 can be seen in Table 2.

Scirpus grossus which was exposed with Al:Fe 0:10.000 and 50:5.000 solution started showing color change in the first day of observation. *Scirpus grossus* leaves turned black, withered, and dry. The observation result was supported by previous study which stated that Fe content beyond optimal level could cause root tissue damage, necrosis, and roots blackening [12]. Physical change showed that Al:Fe had disrupted the metabolism process of *Scirpus grossus*.

TABLE 1.
ENVIRONMENTAL PARAMETERS ON 7 DAYS

Reactor (Al:Fe)	pH	Temperature (°C)	Moisture (%)	Percentage of Living Plants (%)
10.000:0	3,5-6	25-30	100	100
5.000:50	4-5	25-30	100	100
500:500	4,5-5	25-30	100	75
50:5.000	4-5	26-33	100	50
0:10.000	4,5-5	26-35	100	0
Control	4-7	25-30	100	100

TABLE 2.
DAY-7 OBSERVATION OF *SCIRPUS GROSSUS*

Ratio Al : Fe	Scirpus grossus on Day-7 observation	Ratio Al : Fe	Scirpus grossus on Day-7 observation	Ratio Al : Fe	Scirpus grossus on Day-7 observation
10.000:0		5.000:50		500:500	
0:10.000		50:5.000		Control	

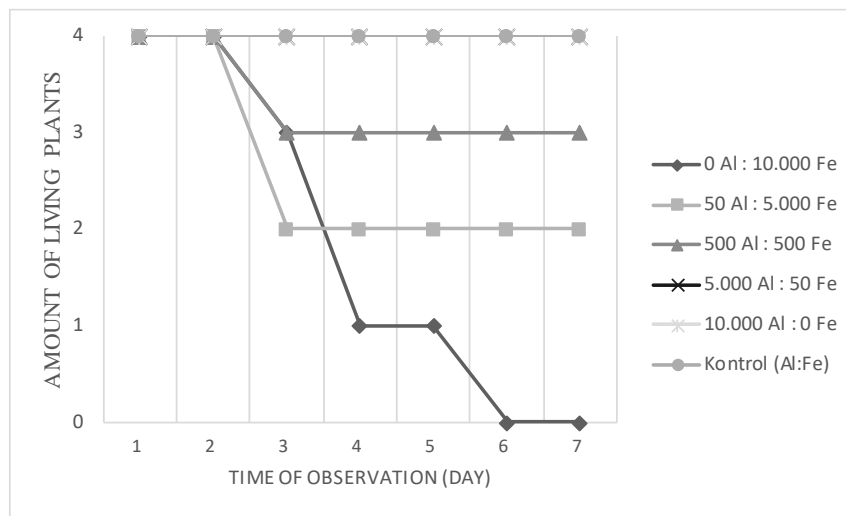


Figure 1. Surviving Plants in RFT

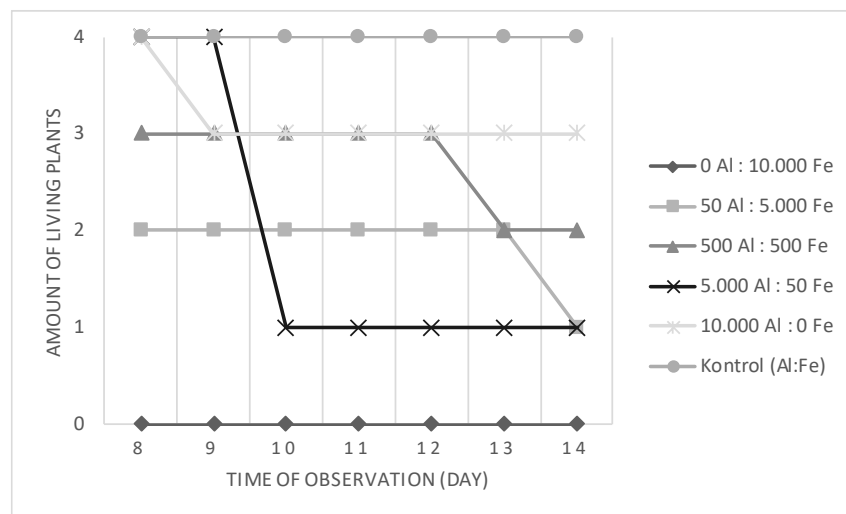


Figure 2. Prolonged RFT

The maximum pollutant load that would be used in phytoremediation should not have been disrupting plants metabolism activity. The combination of Al and Fe can cause damage in *Thymallus thymallus* and *Salmo trutta* [13] because these metals have interaction to each other. In another research [9], *Scirpus grossus* can remove 33% of Al and Fe in 450 mg/L Al and 150 mg/L Fe in waste water. Aluminium in 200-400 mg/kg can disturb the assimilation of plants [14], wheter iron in 1.000 mg/kg can disturb the metabolic process in plants [15].

The pollutant load in this study could be analyzed based on plant death rate in one reactor during observation days. Reactor with Al:Fe 0:10.000 started to show changes in the 3rd day of observation and plants died in day 6. For Al:Fe 50:5.000, 2 plants died in the 3rd day of observation. Al:Fe 500:500 showed death of 1 plant on the 3rd day. The Al:Fe reactor itself only showed change in the 7th day with the death of 1 plant, leaving 3 living plants. The result percentage of living plants for 7 days observation on RFT can be seen on Figure 1.

Based on the above table 1, the surviving plants after 7 days observation were in 10.000:0, 50:5000, 500:500, 5.000:50, and control reactors. In the 7th day of observation.

The living percentage for each reactor were 0% for 0:10.000, 50% for 50:5.000, 75% for 500:500, and 100% for 5.000:50 and 10.000:0 which were compared with control reactor (0:0).

To prove that the maximum Al and Fe can be maintained by *Scirpus grossus* at 500 mg/kg Al and 500 mg/kg Fe, the prolonged RFT has been done. As seen on Figure 2, confirmed that 500:500 was the maximum *Scirpus grossus* can endured because the 14th day of observations, the percentage of living plants in this reactor was about 50% and the plants were in the best condition compare to all the reactors with Al:Fe contaminants that have less percentage of living plants.

IV. CONCLUSION

In this study the toxicity test result stated that *Scirpus grossus* can survive 75% in 500:500 reactor, and 100% for 5.000:50 reactor and 10.000:0 which were compared with control reactor (0 mg/kg Al : 0 mg/kg Fe).

Based on the 7 days observation toward 6 reactors, it could be inferred that the toxicity rate between aluminium and iron were different. Iron had higher toxicity than aluminium, proven by the death of plant with 0 mg/kg

aluminium and 10.000 mg/kg iron load with 0% survival rate, compared with 10.000 mg/kg aluminium and 0 mg/kg iron pollutant load.

REFERENCES

- [1] PEMDA Kabupaten Jombang, "Laporan Informasi Kinerja Pengelolaan Lingkungan Hidup Daerah (LIKPLHD) Kabupaten Jombang tahun 2016," Jombang, 2016.
- [2] IARC Monographs, "List of classifications, Volumes 1–123 – IARC," (*International Agency for Research on Cancer*) IARC Monographs. [Online]. Available: <https://monographs.iarc.fr/list-of-classifications-volumes/>.
- [3] D. Dent, *Acid sulphate soils: a baseline for research and development*. Wageningen: International Institute for Land Reclamation and Improvement/ILRI, 1986.
- [4] B. Ma, L. Gao, H. Zhang, J. Cui, and Z. Shen, "Aluminum-induced oxidative stress and changes in antioxidant defenses in the roots of rice varieties differing in Al tolerance," *Plant Cell Rep.*, vol. 31, no. 4, pp. 687–696, Apr. 2012.
- [5] L. M. Thompson and F. R. Troeh, *Soils and soil fertility*, 3d ed. New York: McGraw-Hill, 1973.
- [6] I. Bodek, W. J. Lyman, W. F. Reehl, and D. H. Rosenblatt, *Environmental inorganic chemistry: properties, processes, and estimation methods*. New York-Oxford: Pergamon Press, 1988.
- [7] A. Kabata-Pendias and H. Pendias, *Trace elements in soils and plants*, 2nd ed. Boca Raton, Florida: CRC Press, 1992.
- [8] J. L. Schnoor, L. A. Light, S. C. McCutcheon, N. L. Wolfe, and L. H. Carreira, "Phytoremediation of organic and nutrient contaminants," *Environ. Sci. Technol.*, vol. 29, no. 7, p. 318A–323A, Jul. 1995.
- [9] N. I. Ismail, S. R. S. Abdullah, M. Idris, H. A. Hasan, N. H. AL Sbani, and O. H. Jehawi, "Tolerance and Survival of *Scirpus grossus* and *Lepironia articulata* in Synthetic Mining Wastewater," *J. Environ. Sci. Technol.*, vol. 8, no. 5, pp. 232–237, May 2015.
- [10] R. W. Crites, E. J. Middlebrooks, R. K. Bastian, and S. C. Reed, *Natural wastewater treatment systems*, Second edition. Boca Raton, Florida: CRC Press, 2014.
- [11] R. Firmansyah, *Mudah dan aktif belajar biologi 3*. Jakarta: Pusat Perbukuan, Departemen Pendidikan Nasional, 2009.
- [12] P. Laan, A. Smolders, and C. W. P. M. Blom, "The relative importance of anaerobiosis and high iron levels in the flood tolerance of *Rumex* species," *Plant Soil*, vol. 136, no. 2, pp. 153–161, Oct. 1991.
- [13] P. J. Vuorinen, M. Keinänen, S. Peuranen, and C. Tigerstedt, "Effects of iron, aluminium, dissolved humic material and acidity on grayling (*Thymallus thymallus*) in laboratory exposures, and a comparison of sensitivity with brown trout (*Salmo trutta*)," *Boreal Environ. Res.*, vol. 3, pp. 405–419, 1999.
- [14] P. Liu, Y. S. Yang, G. Xu, S. Guo, X. Zheng, and M. Wang, "Physiological responses of four herbaceous plants to aluminum stress in South China," *Front. Biol. China*, vol. 1, no. 3, pp. 295–302, Sep. 2006.
- [15] E. L. Connolly and M. Guerinot, "Iron stress in plants," *Genome Biol.*, vol. 3, no. 8, p. reviews1024.1–4, Jul. 2002.